CHAPTER 1

PACKING

GENERAL

PACKING OF GENERAL SUPPLIES

Some commodity items require preservation by procedures and materials described in FM 38-700/MCO P4030.31D/NAVSUP PUB 502/AFJPAM 24-237/DLAI 4145.14, Packaging of Materiel – Preservation, which provide unit containers suitable for shipment without further packing. Other items may require further packing in containers suitable for shipment. This chapter relates to the packing of commodity items directly in shipping containers with whatever protection is required to prevent damage in shipment, handling and storage. The container alone cannot always provide full protection for military items. Items must be properly anchored, braced, blocked, or cushioned in the container to provide adequate protection. A container is often blamed for damage to its contents when the cushioning, blocking, or bracing are at fault (fig. 1-1). Every packing operation, including the final closure, strapping, and marking of the container, must be carefully planned and executed to ensure that the contents will arrive at its destination in a usable condition.

PACKAGING OF HAZARDOUS ARTICLES

Commodities classified as hazardous materials come within the scope of TITLE 49 Code of Federal Regulations which incorporates Department of Transportation Regulation for the Transportation of Explosives and other Hazardous Articles by all modes. International Shipments must be packaged in accordance with the International Air Transport Associations Dangerous Goods Regulation (IATA) and the International Maritime Organization Dangerous Goods Code (IMDG) codes. In addition, hazardous materials which are to be shipped via military aircraft must be packaged in accordance with the joint service manual AFJMAN 24-204/TM 38-250/NAVSUP PUB 505/MCO P4030.19/DLAM 4145.3, Preparing Hazardous Materials for Military Air Shipments.

SEQUENCE OF PACKING OPERATION

The general sequence of military packing is divided into a series of basic operations which may include some or all of the following steps, not necessarily in the order given below:

Determine the Packing Requirements

Knowing the item characteristics helps to determine the protection required and the best way to provide it through the use of an adequate container, suitable blocks, braces, and cushions, and appropriate barrier materials. This study will include consideration of the characteristics of the item, its size, shape, fragility, etc.; the types of loads (easy, average or difficult); the mode of transportation (rail, ship, truck, or aircraft); the storage facilities (covered or uncovered); the destination (domestic or overseas in the arctic, temperate, or tropic zones); and the levels of protection required.

Select the Container

Select and use an exterior container that will comply with the requirements outlined in applicable chapters of this manual. This selection should consider all factors pertinent to giving adequate protection at the minimum cost such as the characteristics and limitations of the container; its initial cost and upkeep expenses; its weight and cube; its availability or obtainability in appropriate quantities; and its reusability.

Prepare protective barriers

Prepare an appropriate barrier to give weatherproofing protection not obtainable from the container alone.

Insert and Secure the Item to the Container

Insert the item and secure it to the container to control or prevent movement by means of adequate cushioning, blocking, and bracing. The distinction between cushioning and blocking is that cushioning permits controlled movement of the item within the container, while blocking and bracing usually is designed to prevent movement of the item within the container.

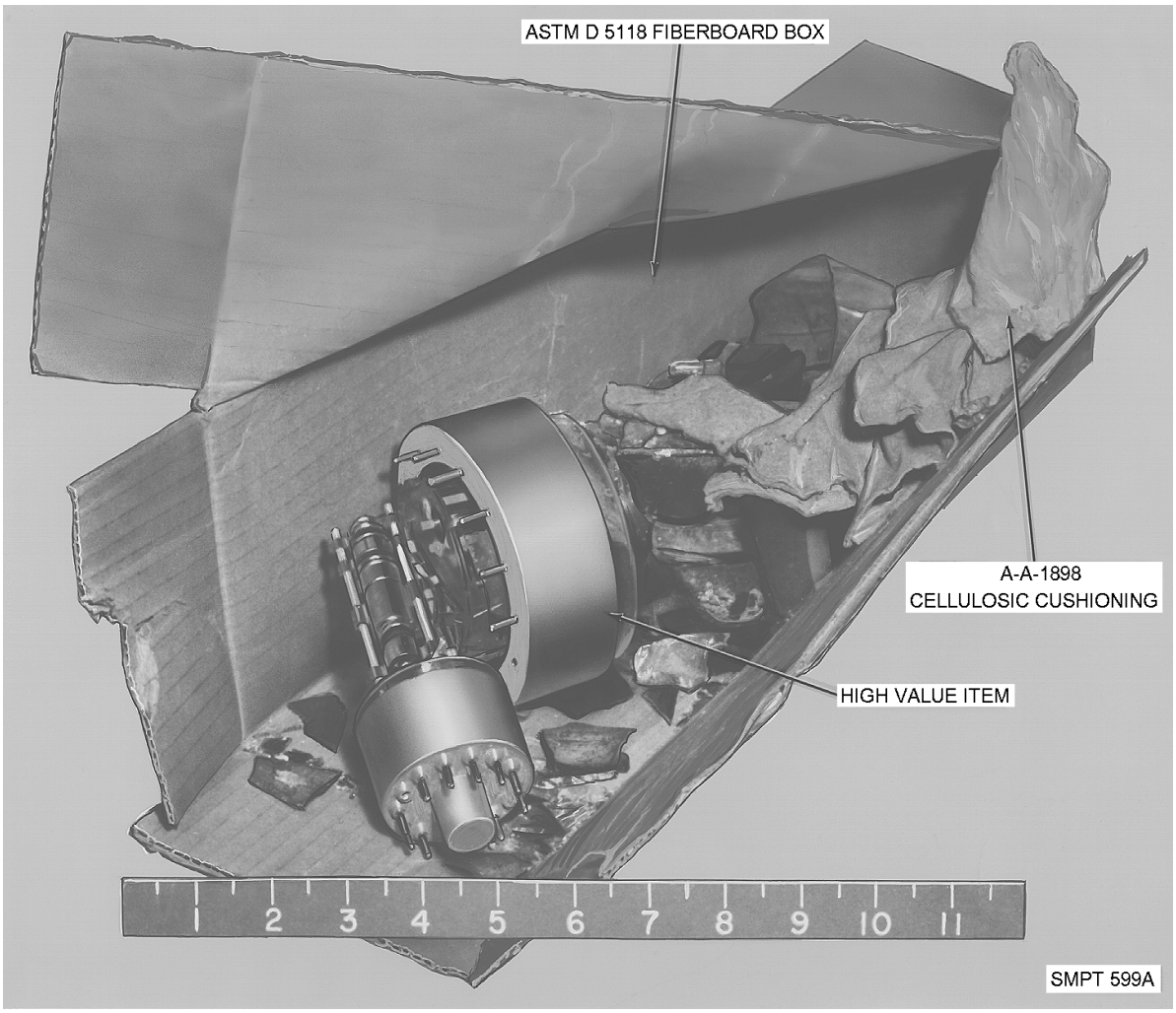


Figure 1-1. Damaged items as a result of improper/inadequate packing.

Seal the Barrier if Used

Seal the barrier material by means of adhesives, heat seals, pressure seals, or sealing tape to provide weatherproofness of the seams, joints, and closures equal to that of the barrier material itself.

Close the Container

Close the container following the detailed requirements outlined in the section of this manual which describes the container selected.

Reinforce the Container. Reinforce the container with metal or plastic strapping or reinforced tape as appropriate and as required for the container selected.

Mark the Shipping Container. Mark the container as appropriate to identify the contents and to ensure movement to its destination.

DETERMINATION OF PACKING REQUIREMENTS

The different types of items procured by the Department of Defense require a wide variety of packing operations. Items vary from strong, rugged ones that fit the container well and require no cushioning, blocking or bracing, to others that are irregular in shape, delicate, or fragile, and require special cushioning, blocking or bracing.

BASIC FACTORS

To determine packing requirements, several basic factors must be considered, namely, the item characteristics, the load characteristics, the mode of transportation, the storage and handling facilities, the destination and field conditions.

BASIC REFERENCE

The basic reference for blocking, bracing, and cushioning is MIL-STD-1186, Cushioning, Anchoring, Bracing, Blocking, and Waterproofing, with Appropriate Test Methods. This standard, approved by the Department of Defense and mandatory for use by the Armed Forces, provides general requirements and procedures concerning the arrangement of the contents within the shipping container for the prevention of physical damage.

SCOPE OF MIL-STD-1186

The standard covers common packing requirements which may be omitted from detail specifications for items or categories of items when this standard is referenced in the detail specification. It does not contain requirements for shipping containers, themselves or for unit packing, both of which also provide physical protection.

ITEM CHARACTERISTICS

The first step in any packaging operation is a careful study of the item to be packed. It is necessary to consider the shape, size, weight, strength, and degree of fragility of the item in all directions. The availability of mounting provisions, the degree of disassembly permissible for shipment, corrosion prevention requirements and special use requirements which affect the packing operations must also be considered.

SHAPE

The shape of the item to be packed is an important factor to consider in designing blocking and bracing. A regular-shaped item with rectangular surfaces requires a minimum of blocking, while an irregular-shaped item with uneven surfaces, including projections, often require an elaborate blocking system. Curved surfaces require carefully fitted blocking to prevent damage caused by concentrated stresses at contact points, and to distribute internal forces over a greater area of the faces of the container (fig 1-2). Long, slender items, particularly if heavy, exert a tremendous concentrated force on the ends of the container during handling. This force may be counteracted by securely blocking the item to the sides, top, or bottom of the container, and by increasing the thickness of the ends of the container (fig 1-3). Relatively heavy, irregular-shaped small items present a particularly difficult problem when they must be cushioned as well as blocked. Generally, in solving this problem, it is desirable to even out the surfaces by means of pads and blocking to increase the bearing area. This in turn decreases the load per unit area of bearing on the cushion (fig 1-4).

SIZE AND WEIGHT

A large item may require more extensive blocking and larger amounts of cushioning than a smaller one. The blocking may be necessary to bridge the relatively wide spans of the container faces, or it may be required to distribute the cushioning over larger areas of the item. Since the impact force developed by the abrupt stopping of a moving object is directly proportional to its weight, the weight of an item is very important in considering the blocking and cushioning. In studying the item, consider the distribution of the weight with respect to the size and bearing areas. Where the weight is concentrated, it may be necessary to distribute it over a larger area. This may be done by transferring some of it from one container face to the edges or corners of the container by the use of end blocks.

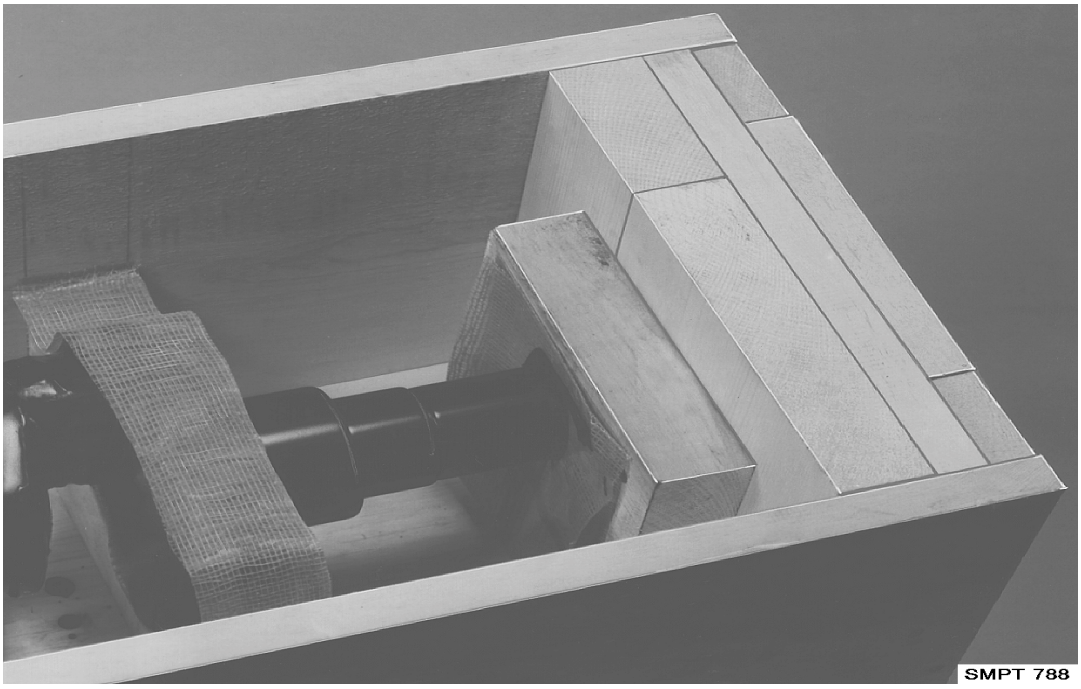


Figure 1-2. Interior blocking for an irregular shaped item.

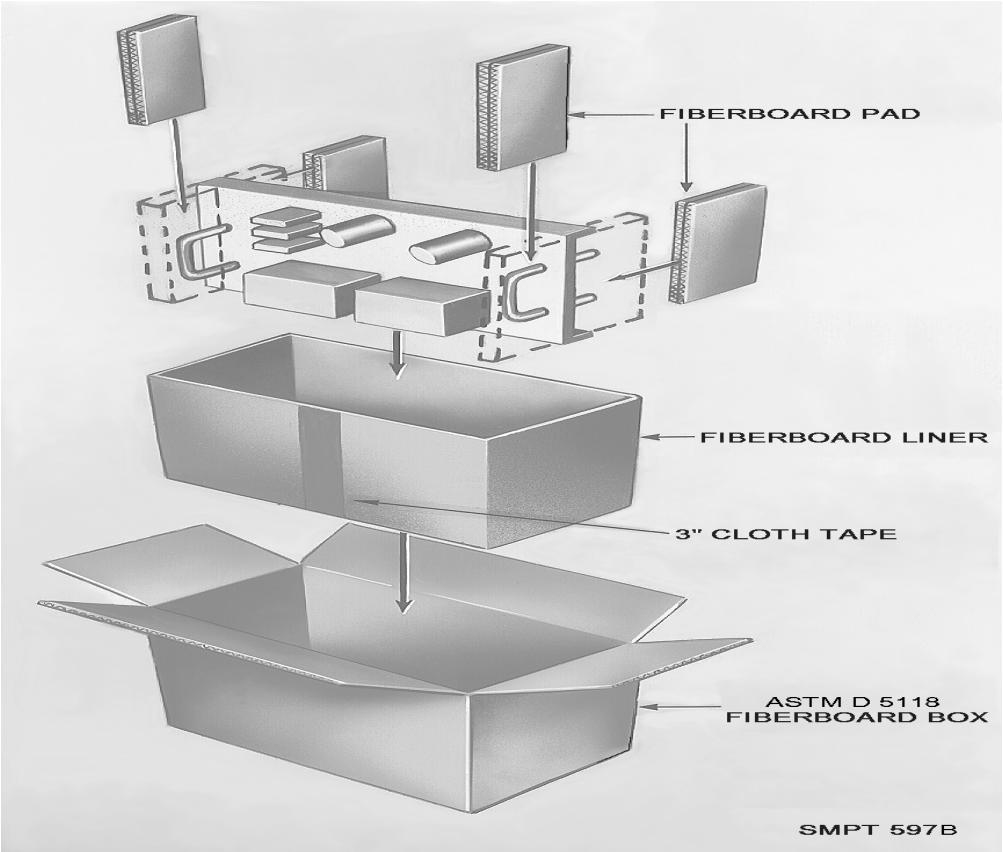


Figure 1-3. Use of corrugated fiberboard pads and liner.

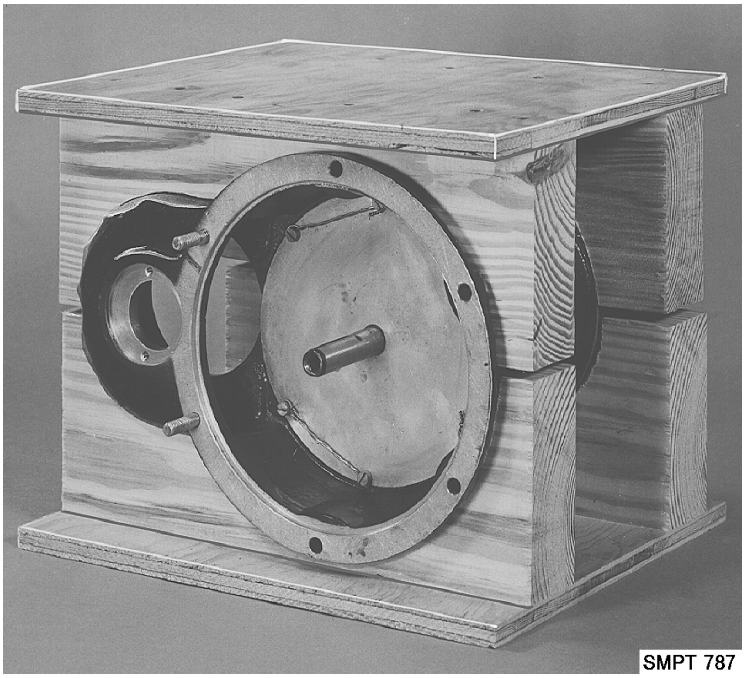


Figure 1-4. Interior blocking to protect container against end thrust.

STRENGTH AND FRAGILITY

Some items are rugged enough to withstand greater stacking loads and handling forces than their containers. Various components of vehicles and tanks, in particular, require little protection against shipping hazards, but are placed in containers for ease of handling, stowage, and storage. On the other hand, there are numerous items that require the maximum protection afforded by packing materials. Equipment is considered rugged or highly resistant to shock when bracing and blocking within the container is all that is needed for protection. Items that require cushioning for protection are considered to be fragile. The degree of fragility of an item determines the amount and type of cushioning required to protect it from damage during handling and shipment. Some items are inherently strong and rugged except for one or more fragile components. When the fragile components cannot be removed for separate packing the entire item must be treated as fragile, even though this may result in an unavoidably large, cumbersome pack.

AVAILABILITY OF MOUNTING PROVISIONS

An important factor to consider in packing is the availability of brackets and holddowns on the item that can be used to mount it within the container. Frequently, it is possible to mount an item within the container by using the same brackets and holddowns that are used for positioning and securing it in place when it is permanently installed. Mounting facilities should be examined to determine if they are adequate, especially if the container is likely to be tipped on end (fig 1-5). Compressors, engines, engine components, generators, starters, and carburetors are often secured in this manner.

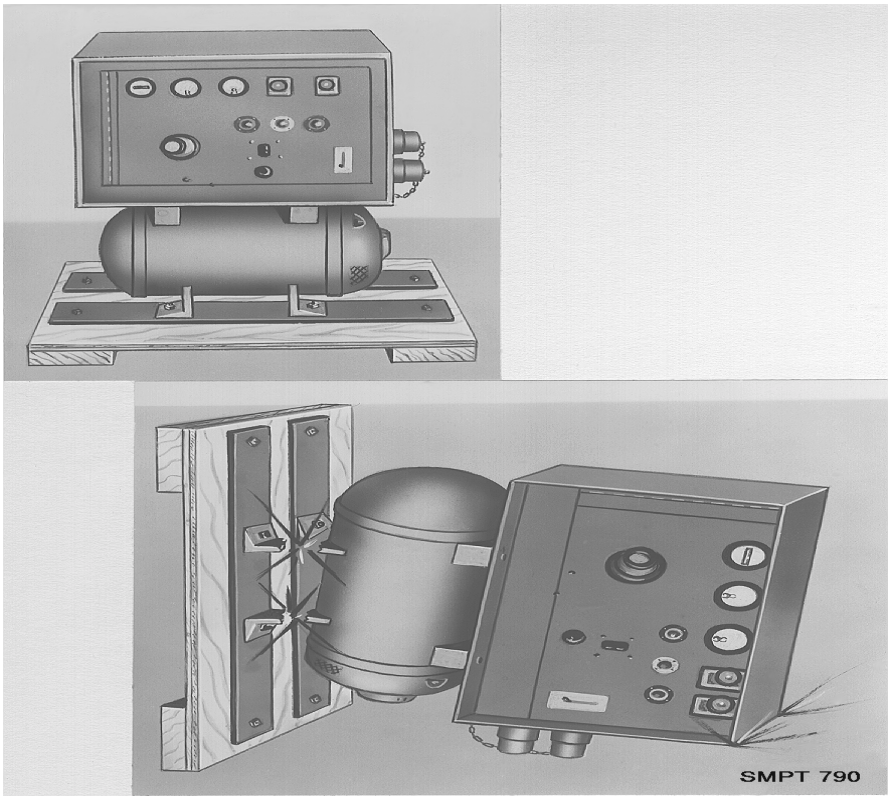


Figure 1-5. Mounting facilities of item must be adequate.

DISASSEMBLING OF AN ITEM

Items should be thoroughly investigated to determine if disassembly of simple parts can reduce the size of the container required and/or simplify the packaging. Proper authorization must be obtained before disassembling any portion of an item that would require technical skills or special tools to reassemble, realign, or recalibrate. The disassembly of simple-to-remove components with standard tools (i.e.., handles, wheels) does not require prior authorization.

Disassembled Parts

When practicable, items should be disassembled to afford protection of components, attachments, and accessories against damage and pilferage and to reduce cubage. Disassembled parts should be wrapped, packaged, anchored, braced, blocked, or cushioned within the shipping container so that parts or protective devices within the shipping container cannot be damaged by mutual contact. Disassembled parts should be clearly and legibly marked as to identity and proper location on the assembled item. All fasteners removed during disassembly should be secured in one of the mating parts. A part should not be removed from an assembly unless it can be reassembled readily in the field without special tools.

CAUTION

Proper authorization must be obtained before disassembling any portion of an item that would require technical skills or special tools to reassemble, realign or recalibrate. Disassembly of simple-to-remove components such as handles, wheels, etc., requiring standard tools, does not need authorization.

SPECIAL PACKING REQUIREMENTS

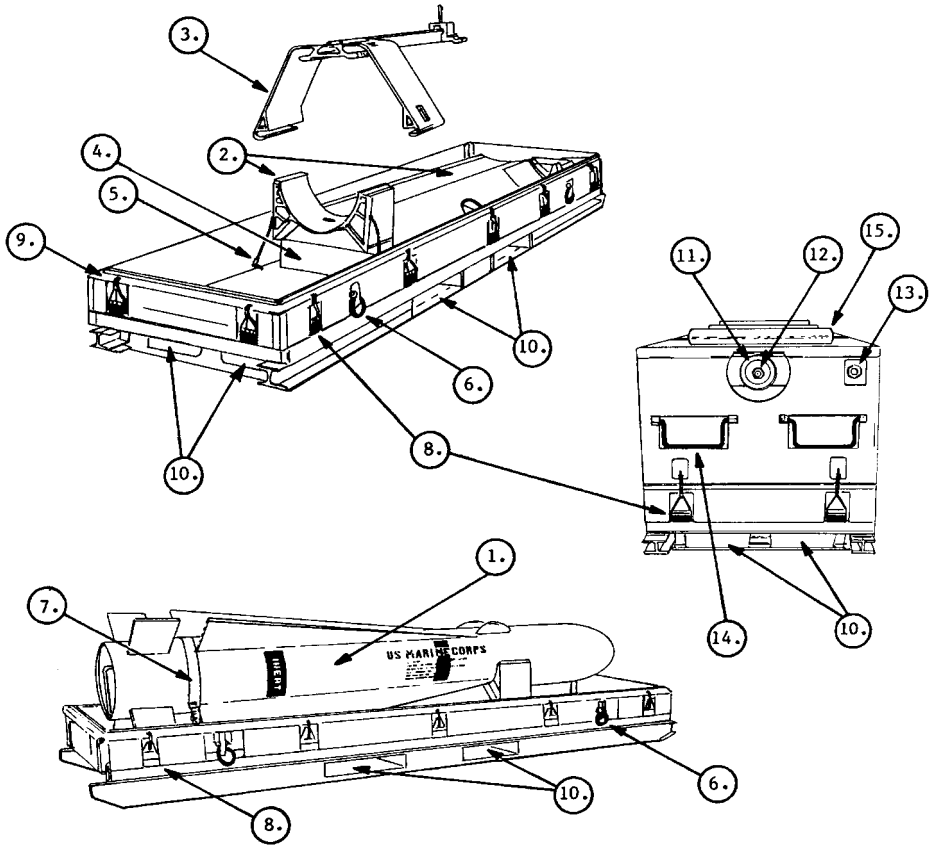
Reusable and other special purpose containers usually require special consideration of the packing of the contents in the container. For instance, in reusable containers, the blocking and cushioning must be arranged so that it may be easily removed, and when replaced, it will adequately protect the contents. However, reusable and special purpose containers should be considered for use, especially if their use results in reduced weight, cube, or cost. For example, the reusable container for a missile nose cone, shown in figure 1-6 while expensive to procure, may more than pay for itself through its reusability and its designed protection features.

LOAD CHARACTERISTICS

The proper selection of the shipping container for a given load is of the utmost importance. The kind of container must be determined by the weight, size, shape, and fragility of the load. To aid in this selection, the various loads have been classified as Type 1-Easy Load, Type 2-Average Load, and Type 3-Difficult Load. (See fig. 3 of the Introduction.)

MODES OF TRANSPORTATION

The mode of transportation is an important factor in determining the packing requirements. The hazards of handling and shipping vary greatly between motor, rail, ship, or aircraft. As an example, there could be considerable difference in the amount of handling that an item being transshipped from truck to rail to ship would receive, and the amount of handling an item delivered by air freight would receive. Likewise, an item



1. MISSLE	6. HOISTING/TIEDOWN/TOWING RINGS	11. DESICCANT PORT
2. CRADLE	7. RESTRAINT STRAP	12. PRESSURE RELIEF VALVE
3. UPPER RESTRAINT	8. LATCH	13. HUMIDITY INDICATOR
4. FOAM CUSHIONING	9. GASKET	14. COVER LIFT HANDLE
5. QUICK-PIN WITH CABLE	10. FORKLIFT POCKETS	15. STACKING INTERFACE

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Figure 1-6. Protection features of a reusable missile container.

to be delivered by airdrop would require much more protection than one to be delivered by truck.

STORAGE CONSIDERATIONS

To assure serviceability of the contents after prolonged exposure to deteriorating elements, not only the supplies, but the packing materials which enclose them must be protected. There may be a considerable period from the time the material leaves the manufacturer until it is used. It may be stored outdoors in domestic depots, then shipped to staging areas or ports of embarkation to await transportation overseas. Finally arriving, it may again be stored in depots or supply areas which could be improvised shacks, native huts, tents, caves, or even in the open. At oversea supply points, the packs are often broken open and smaller intermediate packs distributed to forward areas. On the other hand, items may be shipped directly from the supplier to the user with a minimum of delay. In this instance, the protection provided by the pack could be considerably reduced from the amount required for the oversea pack.

DESTINATION AND FIELD CONDITIONS

The ultimate destination of items is generally unknown when they leave a packing facility. Some items may be used domestically while the rest will eventually go overseas. They may be shipped to the arctic regions, the islands of the seas, or the tropical jungles. They may be subjected to the cold, heat, humidity, aridity, or the extreme temperature changes of the various regions, all of which must be considered in planning the pack to assure adequate protection through the time of delivery and after arrival at destination when they may be subjected to unfavorable field conditions.

FUNCTIONS AND SELECTION OF SHIPPING CONTAINERS

FUNCTIONS

A shipping container is any exterior box, crate, drum, etc., which is required to enclose one or more items during transit or storage. The basic functions of a shipping container are to protect the contents and to provide for ease of handling. Shipping containers assist in the handling of a number of items by consolidation, and of a single item which is difficult to handle. The degree of protection derived from the shipping container depends upon its type, the materials used in its fabrication, its construction features, its final destination, the nature of the contents, and the anticipated hazards. Chapters 2 through 7 of this manual contain information on approved containers for military shipments and should be consulted when making selection of the appropriate containers.

SELECTION

The shipping container is usually established by specifications, directives, technical orders, or other authorized publications. Where a group of containers is authorized, or when the proper container is not specified, the packing supervisor is responsible for the selection of the appropriate container. They must base their selection upon the physical characteristics of the item; its destination; whether domestic or overseas; the level of protection required; the type of load; the initial cost of the container; the weight and cube of the container; the simplicity, economy and ease of assembly and closure; the availability; and need for reusability of the container (fig 1-7). Nailed wood boxes or similar heavy wooden containers will not be used unless fully justified by past experience or environmental, geographical, or security considerations.

ARRANGEMENT OF CONTENTS

The contents of a pack should be arranged within the shipping container so as to provide maximum protection to its contents and the container. Where applicable, the arrangement should permit a container fabricated of materials that will result in low tare weight, smallest practical cube, convenient handling, and suitability for palletization. Contents should completely fill the container or be secured therein with suitable clearance. Packs of like items should contain like quantities and should be uniform in size, shape, and weight.

MOVABLE PARTS AND PROJECTING PARTS

Articles with moving external parts or projecting parts that might become damaged by shock or vibration encountered in shipment should have these parts made secure against movement by means of blocking, bracing, tiedown, or other adequate provisions, or should be disassembled, if practicable.

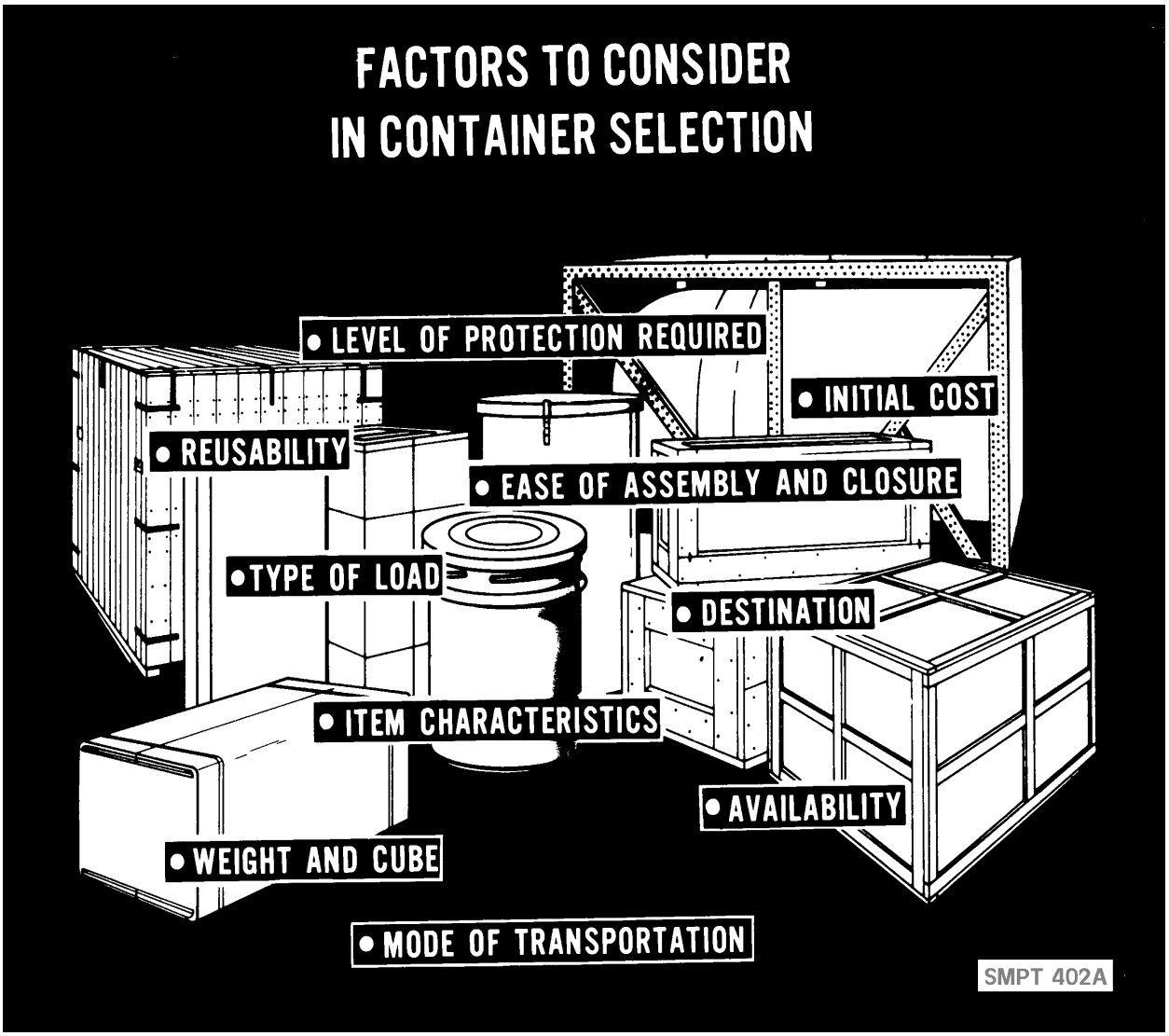

Figure 1-7. Container selection factors.

SEGREGATION OF PACKED CONTENTS

So far as practicable, contents of shipping containers should be segregated in the following order: (a) the order on the packing list; (b) items of the same contract; (c) items of the same National Stock Numbers; and (d) items of the same Federal Supply Class.

CONVERSION OF TYPE 3 LOADS

Where practicable, type 3 loads should be converted to type 1 or type 2 loads.

BLOCKING AND BRACING

BLOCKING AND BRACING DEFINED

Blocking and bracing is the process of providing physical and mechanical protection to an item by means of materials, other than cushioning materials, intended to prevent any free movement of the item within the container, and distribute or transfer concentrated loads of the item to larger areas of other faces of the container.

FUNCTIONS OF BLOCKING AND BRACING

Items which do not completely fill the shipping container should be blocked, braced, anchored, or otherwise immobilized within the container. Blocking and bracing should be used to secure items or components so that they will not shift within a container; to make irregular shaped items fit a regular container; to distribute the weight of irregular items over all edges and faces of the container; to protect projections from injury; to prevent projections from damaging the barrier or container; to provide space for spare parts or make room for desiccant; and to reinforce weak portions or mountings. Blocking and bracing modifies the original shape of an item so that it is protected adequately and so that it fits the container. The materials used for this purpose differ from cushioning in that they are not intended to absorb shocks. Items having legs or other projecting portions which may become loose or broken, or which might puncture the container, must be supported by adequate blocking and bracing. The blocks and braces should be applied against portions of the container that are strong enough to resist forces tending to distort them. Likewise, the bracing should be arranged to distribute forces to several reinforced sections of the surface of the item (fig 1-8). Items with movable parts, items mounted springs or other flexible supports should be braced securely to prevent movement, except where such mounting is part of the package cushioning or is designed to protect against shock and vibration during shipment.

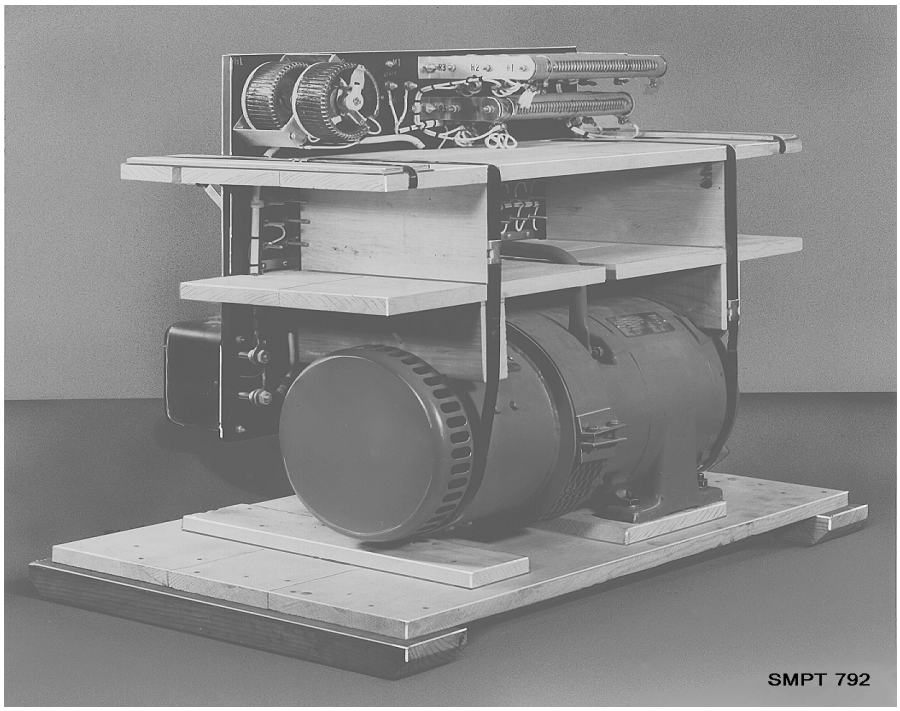

Figure 1-8. Blocking and bracing to prevent movement.

ABRASION PROTECTION

Protection should be provided when the surface of the item in contact with the blocking an bracing can be damaged by relative motion between the contacting surfaces or could become corroded as a result of such continuous contact. Protection against abrasion should be provided for highly finished or easily marred surfaces by wrapping or covering with cushioning material. Surfaces that might be damaged by contact with cushioning material should be separated by a covering of noncorrosive paper conforming to MIL-P-130 or greaseproof barrier material conforming to MIL-B-121, grade A.

APPLICATION OF BLOCKING AND BRACING MATERIALS

The materials selected for all blocking and bracing, the design and application of the blocking and bracing should be compatible with the load to be supported and the size, shape, and strength of bearing areas of the item. The heavier the load needing support, the stiffer and stronger the materials for blocks and braces must be. Hence, the choice of materials depends upon the size and shape of the areas against which the blocking and bracing will be placed, as well as the size and weight of the item being secured. Since a shipping container may be dropped on any of its faces or corners, blocks and braces must be designed to withstand the thrust and impact applied on any direction. The choice of materials used for blocking and bracing vary widely. The chief materials used are corrugated fiberboard in cells, trays, pleated pads, and flat pads, for relatively lightweight items or for supplementary primary blocking of heavy items. Wood, plywood, rigid plastic foams, and metal are used as the primary blocking materials for large and heavy items.

Fiberboard

Open-end cells and trays of corrugated fiberboard. When used as blocking, corrugated fiberboard must be designed to fit the bearing area of the item to support and evenly distribute the load. Common forms of corrugated fiberboard blocking are die-cuts, open end cells, trays, pleated pads, and flat pads (fig 1-9). Frequently, various combinations of these forms are employed. They can be used to provide spaces for, and restrain the movement of, disassembled parts, as well as provide openings for bags of desiccant. Generally, cells and trays should be held in shape with tape or staples.

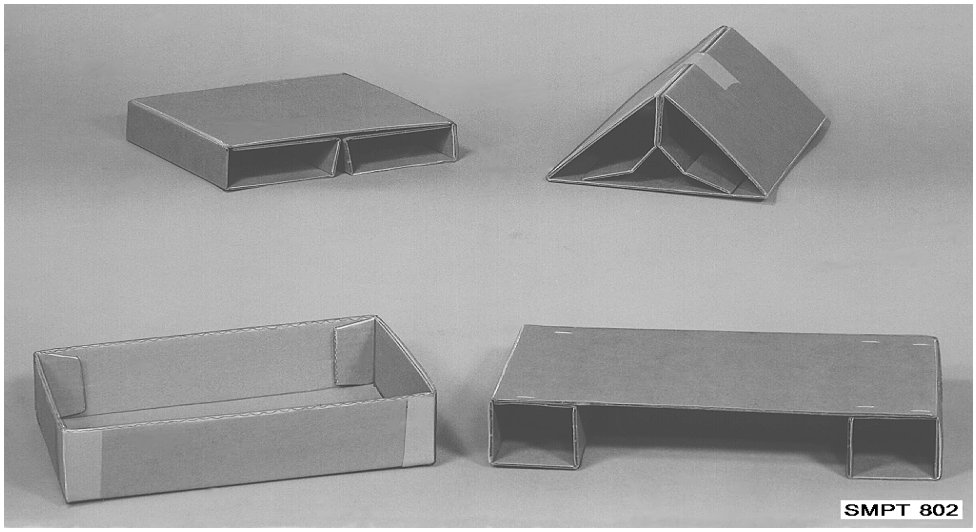

Figure 1-9. Cells and trays made of corrugated fiberboard.

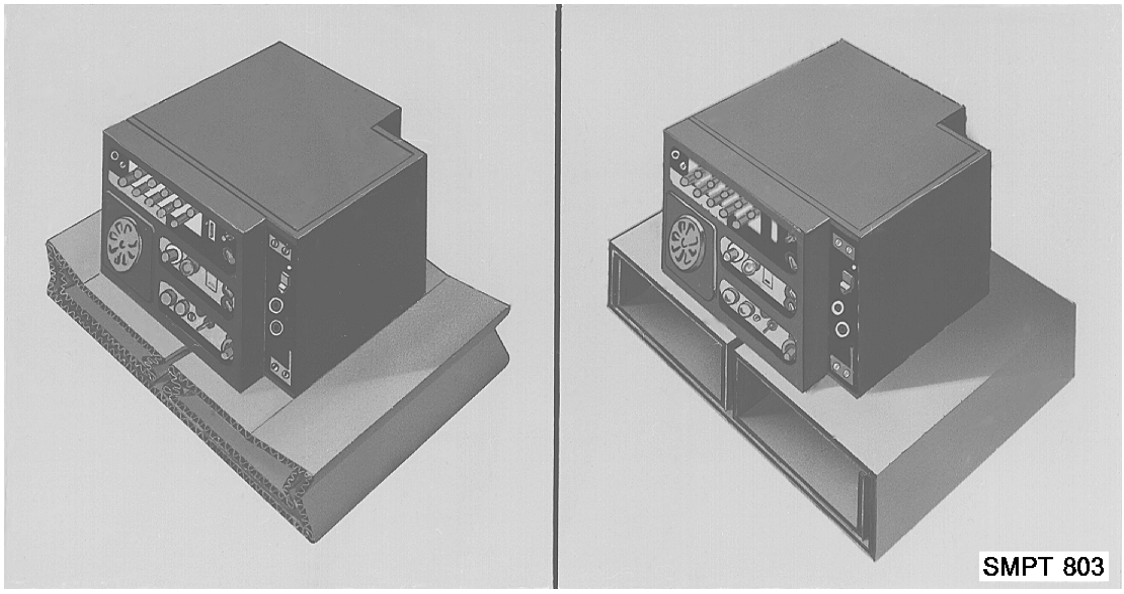

Figure 1-10. Incorrect and correct direction of corrugation.

Those surfaces of the cell or tray which are perpendicular to the contacting surface of the item are called bracing supports and are the load bearing members. No bracing support allowances should be made for the other surfaces. To utilize all of the strength of these bracing supports, they should bear directly on the item. The weight of the item must be exerted in the same direction as the corrugations. If not, the item is inadequately supported and damage may result (fig 1-10). Open-end cells and trays should be used for blocking and bracing deep recesses; bridging long projections; providing spaces for disassembling parts, accessories, and dessicants; and providing clearance between item and container. Bracing supports should bear directly on the article. Allowable loads for bracing supports of open-end cells loaded in the flute direction should be in accordance with table 1-1. If flute direction is at right angles to the direction of the load, the allowable loads should be 50 percent of the values of table 1-1. Trays should be scored and folded parallel to the flute direction and should not exceed 4 inches in height.

CORRUGATED FIBERBOARD FORMS

Corrugated fiberboard used for blocking and bracing should conform to ASTM D 4727. Blocking and bracing forms should be loaded in the direction parallel to the flutes wherever possible. The cutting, slotting, scoring, and folding of fiberboard blanks to make blocking and bracing supports or forms shall be such as to assure proper fitting and distribution.

FOLDED PADS

Folded pads of corrugated fiberboard may be used for blocking greater loads than are feasible to support with cells and trays. The pads should be designed to fit against a flat surface (flat pads) or along an edge (corner pads). Connecting webs between flat pads should always contact the container and not the item. All scores and folds should be made at right angles to the flute direction. Flat pads should be a minimum of 2 inches wide. Portions of folded pads in direct contact with the item are bearing areas. The maximum loads for these bearing areas should be in accordance

Table 1-1. Allowable loads for corrugated fiberboard. Columns loaded in the flute direction.

Material	Allowable loads per lineal inch of bracing support or column	
	Height up to 4 inches	Height over 4 inches
	Pounds	Pounds
Double-faced fiberboard:		
200-pound bursting strength	2	1
275-pound bursting strength	2.5	1.5
350-pound bursting strength	3	2
Double-wall fiberboard:		
275-pound bursting strength	2.5	1.5
350-pound bursting strength	3	2
500-pound bursting strength	4	2.5
Triple-wall fiberboard:		
1,100-pound bursting strength	5	4

Note. When a greater load is imposed than that permitted by the table, use wood blocking and bracing

with table 1-2. Accordion folded pads have greater resistance to breakdown than open end cells because the load is spread over a large area rather than on bracing supports. Accordion folded pads with tight folds distribute the load more evenly to the container. The connecting web between the folded pleats should be placed in contact with the container rather than the item. Creases for accordion folded pads should be made across the corrugations, and the pleat should be at least 2 inches in width. If necessary, a pleat 1 1/2 inches wide may be made, but extreme care must be exercised when folding the pad to prevent crushing the corrugations. Tape should be used to keep accordion folded pads in shape. The load bearing capacity of a pad is based on the initial compressibility of the corrugated material. Increasing the number of pleats does not increase the safe load limit; numerous pleats increase the cushioning value only. Wide or long items are better supported by several accordion folded pads, placed side by side, than by one pad having extremely wide folded pleats.

FLAT PADS

Flat pads of corrugated fiberboard may be used to block very shallow projections, such as hinges or slight offsets on surfaces; to level off projecting screw heads; to fill in the space between ends of inner flaps of slotted fiberboard boxes to provide additional protection to contents at top and bottom of boxes; and to separate items within a container. Allowable loads should be in accordance with table 1-2. Maximum allowable loads per square inch of bearing area on a flat pad are the same as those for a pleated pad. Flat pads can be slotted to form partitions, or they may be die cut or punched to fit items or irregular shape. Figure 1-11 shows the assembling of slotted fiberboard partitions.

Table 1-2. Allowable loads for folded corner and flat pads of corrugated fiberboard

Flute design	Maximum allowable load for bearing areas
	Pounds per square inch
A-flute (36"3 corrugations per foot)	2.0
B-flute (50"3 corrugations per foot)	3.0
C-flute (42"3 corrugations per foot)	2.5

Note. The flat crush resistance of the corrugations shall determine the load that may be carried in flat loading of corrugated fiberboard. This shall not be construed to meet the bursting strength of the material.

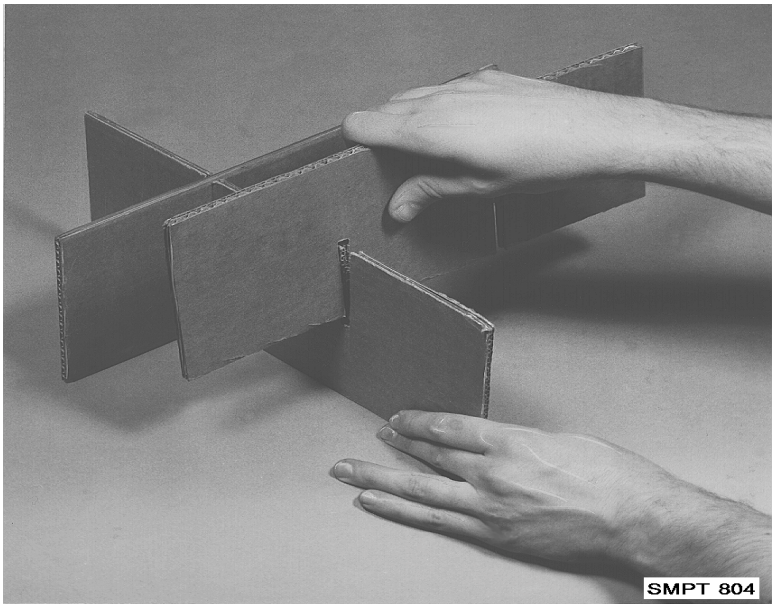

Figure 1-11. Assembling of slotted fiberboard partitions.

CORNER PADS

The use of corner pads made of multiple layers of corrugated fiberboard shall comply with the load requirements of table 1-2. The pads shall provide required clearances and support for rectangular shaped items or for an inner box in which items are packed.

TUBES

Fiberboard tubes should be used as blocking when items mounted on an auxiliary base are packed on fiberboard boxes. The bottom of the tube shall contact the top of the auxiliary base and the top of the tube shall contact the top inside surface of the container. The flutes shall be oriented in the top-to-bottom direction of the tube. The weight of the item plus auxiliary base, in pounds, divided by the perimeter of the tube, in inches, shall not exceed the appropriate values given in table 1-2 for column heights over 4 inches.

CORRUGATED FIBERBOARD LINERS

A liner is a continuous pad, bent to fully contact two or more inner faces of a container. Liners are used to reinforce a container against crushing by forces imposed during stacking, or to take the place of two or more flat pads. A liner may also be used as a holddown for base mounted items weighing not more than 20 pounds. The creases in a liner should be made parallel to the

direction of the corrugations of the fiberboard, in order that the resistance to forces ordinarily encountered in stacking be the greatest.

CORNER POSTS

Fiberboard corner posts should be used to reinforce the shipping container and provide blocking for platform-mounted equipment. The flutes should be oriented in the top-to-bottom direction. The bottom end of the corner post shall bear uniformly on the platform, and the top end of the corner post shall bear on the inner flap of the container or top member of a crate. Corner posts, when installed, must so interlock with the contents and other inner padding pieces in order not to become displaced during transportation.

WOOD OR PLYWOOD

Wood or plywood may be used alone or in combination for blocking and bracing. Wood or plywood blocking and bracing members should bear against only those parts of the packed item capable of withstanding the applied dynamic forces or should bear against blocking pads or pressure strips that adequately distribute these forces. Wood or plywood blocking and bracing should be designed to permit easy removal without damage to the item. Both wood and plywood are used for blocking and bracing because of their high strength-weight ratio, general availability, and ease of cutting and fastening. Lumber has certain weaknesses, such as low splitting resistance parallel with the grain, and a tendency to shrink or swell with change in moisture content.

Plywood has high resistance to splitting and high dimensional stability with changes in moisture content. Because they are more resistant to splitting than solid wood, plywood panels are more often used in thinner dimensions than lumber, and are readily nailed or fastened with screws near the edges. Plywood is more apt to have a lower moisture content than lumber because of the manner in which it is manufactured and stored. Plywood, being constructed of alternate plies at right angles to each other possesses more uniformly distributed strength properties than lumber. When considering lumber and plywood of comparable sizes and quality, it is generally true that the strength properties of lumber parallel to the grain are greater than the respective strength properties of plywood parallel to the grain of the face ply. It is also true that the strength properties of lumber perpendicular to the grain are generally less than the respective strength properties of plywood perpendicular to the grain of the face ply.

WOOD

Wood members of each size and type used in the blocking and bracing should be tested for moisture content. Structural members (those subject to critical bending stresses) shall conform to class 1. All other blocking and bracing members shall conform to class 3. Whenever possible, wood blocks or braces shall be placed so that the load is applied against the end grain of the member. Ends of braces shall be socketed or fitted and secured into appropriate notches in load-bearing members.

PLYWOOD

Plywood used for blocking and bracing should conform to A-A-55057.

WOOD BLOCKING AND BRACING

The species of woods differ greatly in strength and related properties and, accordingly, have been separated into four groups. Certain species, such as those of Group IV, excel in toughness and shock resistance, but care must be exercised in nailing them to avoid splitting. Other species, such as southern yellow pine and Douglas fir of Group II, are high in bending strength and stiffness; and nailing is a lesser problem. The characteristics of the groups of wood may be used to advantage in various forms of blocking and bracing (fig. 1-12). Thin pieces of lumber split more easily than thick pieces; hence, thin pieces for blocking should be avoided if possible. If the dimensional limits of the item require that the blocking be thin, it is preferable to use plywood.

MOISTURE CONTENT

The moisture content of lumber employed as blocking and bracing material should not exceed 19 percent nor be less than 12 percent of its oven dry weight at the time of fabrication. Shrinkage is objectionable because it allows movement of the item and the item may actually break loose. Moisture in lumber is objectionable because it is apt to evaporate into the pack, thus raising the humidity of the pack and causing corrosion of metals or decay of organic materials.

CAUTION

Lumber, plywood, or other hygroscopic materials should never be placed in direct contact with critical metal surfaces since such materials tend to absorb and retain moisture next to the surfaces, finally causing corrosion. Provide always a water-vaporproof barrier between any critical metal surfaces and hygroscopic packing materials, and a waterproof or moisture-resistant barrier between all metal surfaces and hygroscopic materials.

DEFECTS IN BLOCKS AND BRACES

Wooden members used for blocking and bracing are often subjected to great stress and careful consideration must be given to any weakening defects. If the member functions as a beam or column, defects such as divergence of grain, knots, splits and decay should be avoided. This is especially important if the defect is located near the center of the piece, because of the great reduction in shock resistance. If a piece with a knot is used, the load is placed so that the knot is in compression as shown in ②, Figure 1-12. Lumber having knots of a diameter exceeding one-fourth the width of the piece should not be used (fig 1-12). The slope of grain in each piece should not exceed 1 inch in 10 inches of length, or splitting is likely to occur. Decayed wood is avoided under all circumstances because there is not way of determining how much the decay may have weakened the wood. For additional information on wood knots, see chapter 3 and figure 3-3.

Size of Wood Braces of Holddowns

Braces or holddowns must be of sufficient size to withstand the shocks encountered. The size of a brace varies with the weight of the item, the length of the brace, and the type of loading. Table 1-3 used with figure 1-13 gives the recommended allowable load in pounds for the various sizes of braces and the various types of loading. For example, assume that the weight of the item is 60 pounds, the length of the brace is 24 inches, and the type of loading is the third type illustrated in figure 1-13 (loading in the

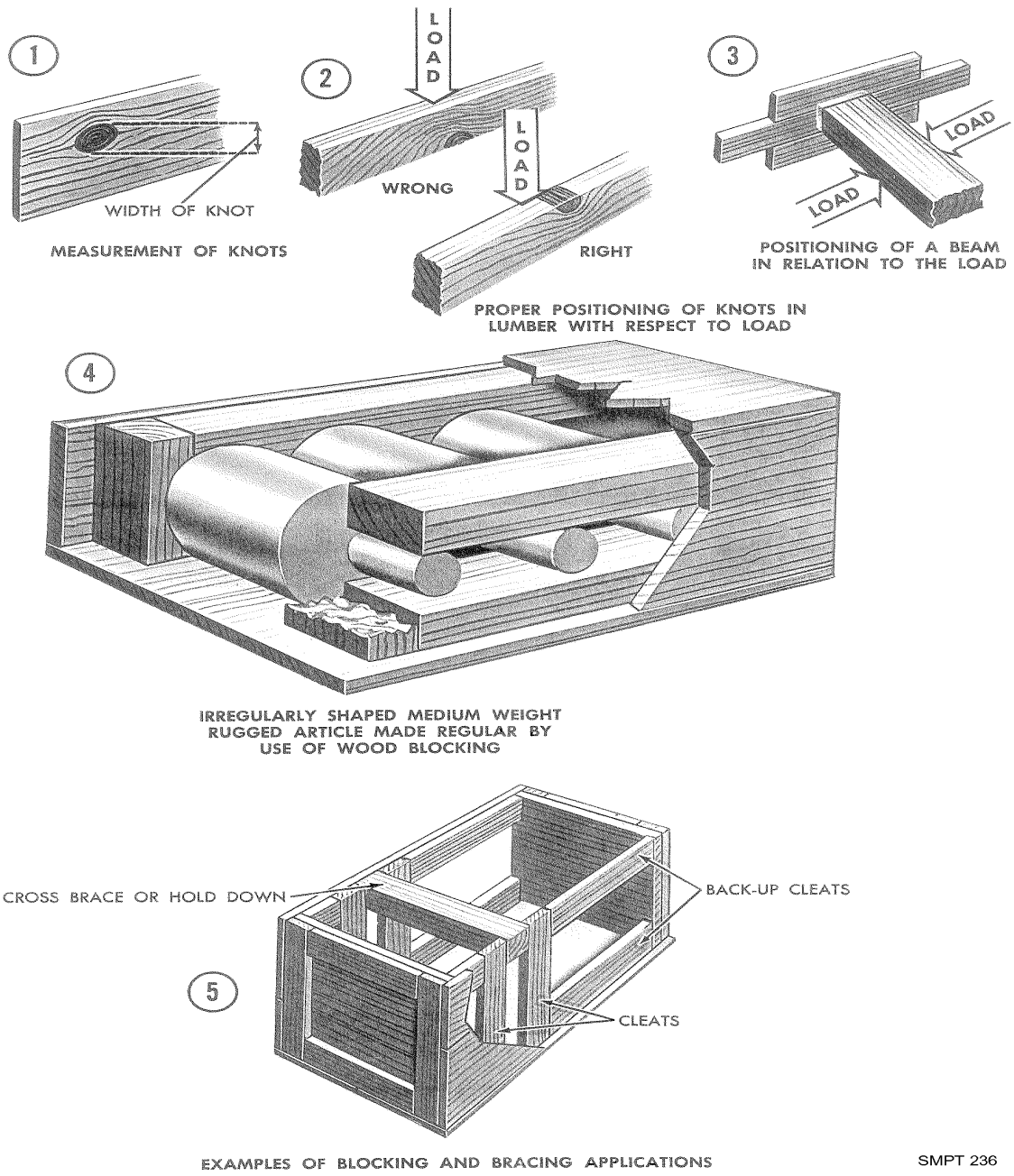

Figure 1-12. Application of wooden blocks and braces.

Table 1-3

THE ALLOWABLE LOAD IN POUNDS IS FOR GROUP II WOODS

LENGTH OF BRACE IN INCHES	1 X 1		1 X 2		1 X 3		1 X 4		1 X 6		1 X 8		2 X 2		2 X 3		2 X 4	
12	23	23	47	94	78	225	109	315	172	495	227	653	187	187	313	450	438	630
18	16	16	31	63	52	174	73	315	115	495	151	653	125	125	208	347	292	630
24	12	12	23	47	39	130	55	255	86	495	113	653	94	94	156	260	219	510
30	10	10	19	37	31	104	43	204	69	495	91	653	75	75	125	208	175	408
36	8	8	16	31	26	87	36	170	57	420	76	653	62	62	104	174	146	340
42	7	7	13	27	22	74	31	146	49	360	65	626	54	54	89	149	125	292
48	6	6	12	23	20	65	27	128	43	315	57	548	47	47	78	130	109	255
54	5	5	10	21	17	58	24	113	38	280	50	487	42	42	69	116	97	227
60	5	5	9	19	15	52	22	102	34	252	45	438	37	37	63	104	88	204
66	4	4	8	17	14	47	20	93	31	229	41	398	34	34	57	95	80	186
72	4	4	8	15	13	43	18	85	29	210	38	365	31	31	52	87	73	170
78	4	4	7	14	12	40	17	78	26	194	35	337	29	29	48	80	67	157
84	3	3	6	13	11	37	16	73	25	180	32	313	27	27	45	74	62	146
90	3	3	6	13	10	35	15	68	23	168	30	292	25	25	42	69	58	136
96	3	3	6	12	10	33	14	64	22	158	28	274	23	23	39	65	55	128
102	3	3	6	11	9	31	13	60	20	148	27	258	22	22	37	61	51	120
108	3	3	5	10	9	29	12	57	19	140	25	243	21	21	35	58	49	113
114	2	2	5	10	8	27	12	54	18	133	24	231	20	20	33	55	46	107
120	2	2	5	9	8	26	11	51	17	126	23	219	19	19	31	52	44	102

LENGTH OF BRACE IN INCHES	2 X 6		2 X 8		3 X 3		3 X 4		3 X 6		3 X 8		4 X 4		4 X 6		4 X 8	
12	688	990	906	1305	750	750	1050	1050	1650	1650	2175	2175	1470	1470	2310	2310	3045	3045
18	458	990	604	1305	579	579	810	1050	1273	1650	1678	2175	1470	1470	2310	2310	3045	3045
24	344	990	453	1305	434	434	608	851	955	1650	1259	2175	1191	1191	1872	2310	2467	3045
30	275	990	363	1305	347	347	486	681	764	1650	1007	2175	953	953	1497	2310	1974	3045
36	229	840	302	1305	289	289	405	567	637	1400	839	2175	794	794	1248	1961	1645	3045
42	196	720	259	1251	248	248	347	486	546	1200	719	2086	680	680	1069	1681	1409	2920
48	172	630	227	1095	217	217	304	425	477	1050	629	1825	595	595	936	1470	1234	2555
54	153	560	201	973	193	193	270	378	424	934	559	1622	529	529	832	1307	1096	2271
60	138	504	181	876	174	174	243	340	382	840	503	1460	476	476	749	1176	987	2044
66	125	458	165	796	158	158	221	309	347	764	458	1327	433	433	681	1069	897	1858
72	115	420	151	730	145	145	203	284	318	700	420	1217	397	397	624	980	822	1703
78	106	388	139	674	134	134	187	262	294	646	387	1123	366	366	576	905	759	1572
84	98	360	129	626	124	124	174	243	273	600	360	1043	340	340	535	840	705	1460
90	92	336	121	584	116	116	162	227	255	560	336	973	318	318	499	784	658	1362
96	86	315	113	548	109	109	152	213	239	525	315	913	298	298	468	735	616	1278
102	81	297	107	515	102	102	143	200	225	494	296	859	280	280	440	692	580	1202
108	76	280	101	487	96	96	135	189	212	467	280	811	265	265	416	654	548	1136
114	72	265	95	461	91	91	128	179	201	442	265	768	251	251	394	619	519	1075
120	69	252	91	438	87	87	122	170	191	420	252	730	238	238	374	588	493	1022

LUMBER CROSS SECTION SIZES AS SHOWN IN TABLE ARE NOMINAL.

THE ALLOWABLE LOAD IN POUNDS AS SHOWN ARE FOR ACTUAL OR DRESSED SIZES - EXAMPLE : 11/2 x 31/2 = 2 x 4 ETC.

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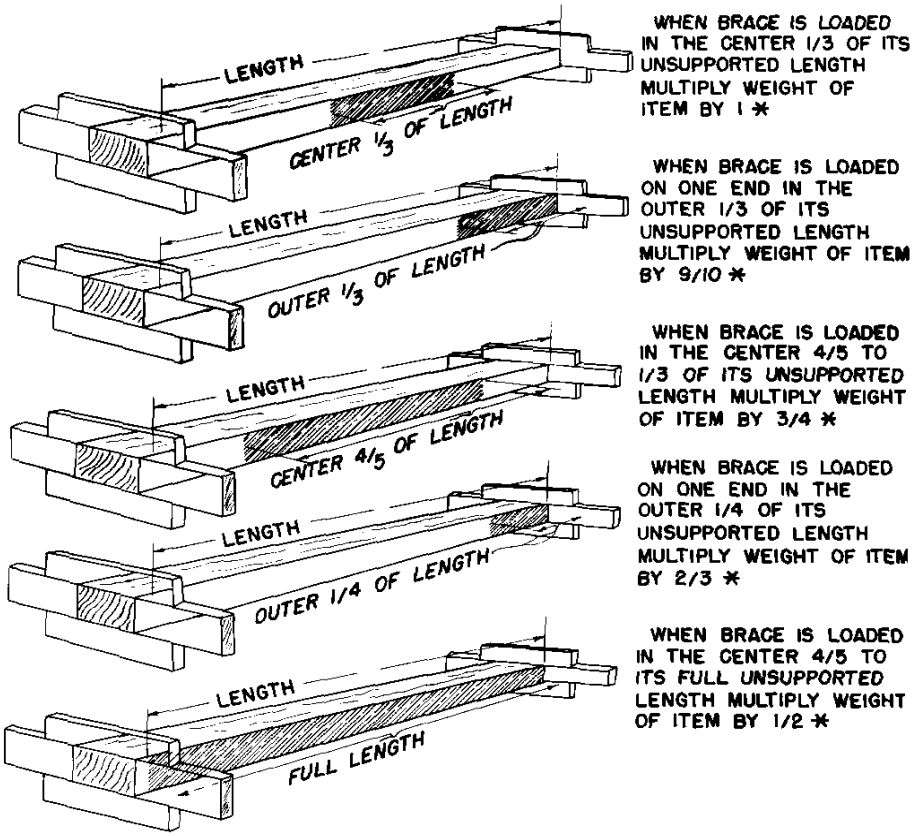

Figure 1-13. Types of loading (use with table 1-3).

center 4/5 to 1/3 of the unsupported length of the brace). For this type of loading, multiply the weight of the item by the factor 3/4, as shown in figure 1-13. Three-fourths times 60 equals 45. In the column headed "Length of brace in inches", of table 1-3, find 24 inches and read to the right until a value near 45 is found. The heading for this column shows that the proper size of member and direction of loading is a 1 x 2-inch member used on edge, or a 1 x 4 inch member used flatwise.

POSITIONING LOADS ON BLOCKS AND BRACES

When wood blocking and bracing is used to secure heavy items, place the block so that the load rests on the end grain of the piece, whenever possible. If this cannot be done, the load should bear on the edge grain. When so placed, the maximum strength of the brace is used (fig 1-14). Since wood is relatively stable in dimension along the grain, there is little effect from shrinkage or swelling with a change in moisture content. The brace should, if possible, have its narrow face against the item so that its maximum stiffness is utilized. If a larger bearing area is required, and it becomes necessary to have the flat face of the brace against the item, the size of the brace against

the item, must be increased (table 1-3). Lumber which is relatively wide for its thickness must be reinforced throughout its length to prevent twisting or buckling.

USING LUMBER AS A MOUNTING BASE

If an item is to be secured to a base, and plywood is not available, use dimensional lumber. Bases of dimensional lumber should be constructed with sufficient cleats at right angles to the grain of the baseboards, and fastened with clinched nails to prevent the boards from splitting at the bolt holes. Strength of the bases must be adequate to withstand any rough handling the pack may be likely to receive.

SECURING LUMBER BLOCKING

Securing lumber blocking properly is the most essential factor in blocking and bracing. Wooden braces positioned between two faces of a container should never be secured with end grain nailing, toenailing, or similar methods, nor should they ever be inserted into notches cut into the container faceboards. Instead, the braces should be secured by cleats fastened to the faces of the container with a sufficient number of clinched nails. When pressures are great or an increased nailing area is required, backup blocks are used to reinforce the cleats and give increased nailing area. When pressure is from more than one direction, a pocket cleat arrangement is used to hold the braces in position ③ fig 1-12. The backup blocks are positioned with their end grain in contact with the brace in order to make use of the high strength property of wood in compression parallel to the grain. The cleats and backup cleats ⑤ fig 1-12 are secured with clinched nails properly staggered at intervals along their length. Sometimes, however, bolts are used to fasten these members in place. This is especially desirable when the entire weight of the item thrusts against the block, or when the cleat supports a framework attached to one or more faces of the container.

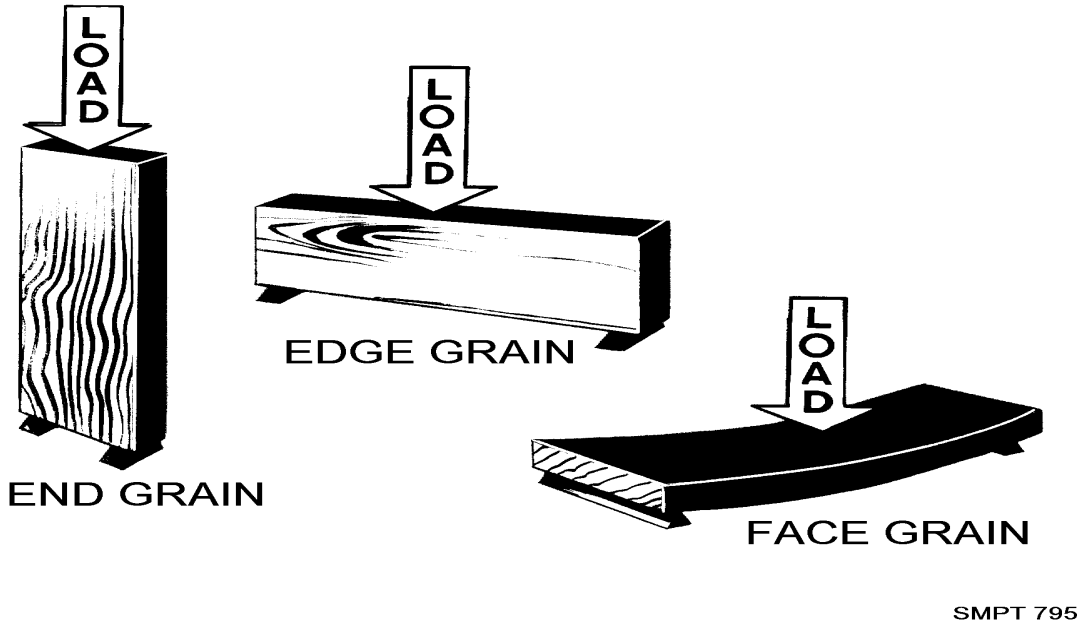

Figure 1-14. Positioning load according to grain of wood

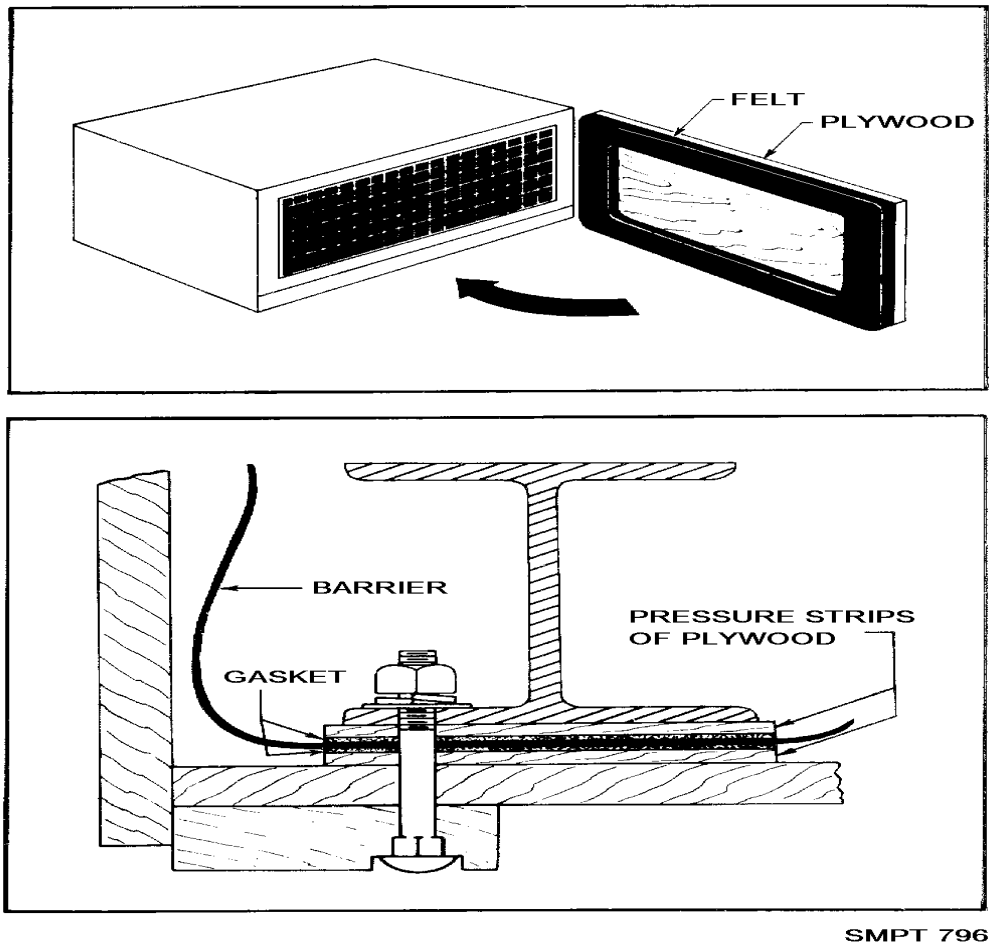

Figure 1-15. Protection for barrier and item surfaces.